NOTES ON WOLFRAMITE, BERAUNITE, AND AXINITE.

By Edgar T. Wherry,
Assistant Curator, Division of Mineralogy and Petrology, United States National Museum.

OBSERVATIONS ON WOLFRAMITE.

The studies herein presented were undertaken at the suggestion of Mr. Frank L. Hess, of the United States Geological Survey, who desired information as to the composition of these two occurrences of wolframite.

No. 1 is a large specimen in the exhibition collection of the Museum (Cat. No. 80179), labeled "Cornwall, England," although unfortunately with no statement as to the exact mine or district from which it came. It shows, however, the characteristic features of the mineral as found in that region, occurring as long bladed crystals, with granular chalcopyrite, in white vein quartz. Along cracks in the solid wolframite a yellowish powder is developed, which apparently represents an alteration product, although the amount is too small to determine its character.

No. 2 is a mass about 6 by 9 by 12 cm. in size, showing a very black wolframite intimately associated with bright green chrysocolla, with here and there between the two, as well as throughout the wolframite, streaks of an olive green, waxy, copper tungstate mineral. The associated gangue minerals are microcline and gray quartz, the occurrence being evidently in a pegmatite vein. It came from Cave Creek, north of Phoenix, Arizona, and was presented to the Museum by Mr. S. H. Brockunier, through Mr. Hess (Cat. No. 87283).

Material for analysis was selected from portions free from visible impurities, finely powdered and dried in a dessicator over sulphuric acid. Preliminary trials of the method of distillation in a stream of sulphur monochloride mixed with chlorine, recently recommended by Bourion,[1] gave rather unsatisfactory results in that it was extremely difficult to recover all the tungsten, some of it sticking to the glass apparatus, and further, although most of the manganese and all the silica, calcium, copper, and magnesium remained behind in the boat, some iron was also left, so that it was necessary to run

[1] Ann. chim. phys., ser. 8, vol. 21, 1910, p. 87.

both the residue and the distillate through the whole course of analysis.

The method of fusion with sodium carbonate as outlined by Treadwell[1] was therefore adopted, although modifications had to be introduced to obtain the copper in No. 2. The rare metals were also separated by the course recommended by Treadwell, that of decomposition by nitro-hydrochloric acid. It was found that on washing the residue insoluble in ammonia with pure water, the oxides of columbium and tantalum tended to become colloidal and run through the filter paper, a turbid filtrate under these conditions constituting a very delicate test for their presence; adding a little ammonium nitrate to the wash water coagulated them again, however, and permitted their retention on the filter.

In sample 1 the unusually high value of 0.80 was obtained for calcium. As it seemed of interest to know whether this was due to included calcite gangue, or to scheelite, half a gram was ignited for 30 minutes in a platinum crucible at the highest temperature of a modern complete combustion burner, and tested with neutral phenolphthalein solution. Not the slightest alkalinity was shown, although calcite should have been readily decomposed under these conditions. It was then thought that treatment with tartaric acid might throw some light on the question. Half a gram of the sample was heated on a steam bath with a solution of 10 grams of tartaric acid in 50 cc. of water for three hours, the undecomposed mineral filtered out, and ammonium hydroxide and ammonium oxalate added to the filtrate. On standing overnight a precipitate of calcium oxalate came down, which on being filtered out, ignited, and weighed, gave 0.82 per cent, showing that all the calcium had gone into solution. In the filtrate from the calcium oxalate ammonium sulphide gave a black precipitate of ferrous sulphide, which was filtered out, dissolved in hydrochloric acid, and its iron precipitated with ammonium hydroxide and weighed as ferric oxide. A small amount of manganese oxide, determined as 0.07 per cent, was also recovered here. The filtrate, from which iron, manganese, and calcium had now been completely removed, was evaporated to dryness three times with concentrated nitric acid to destroy the tartaric acid, and the separated tungsten trioxide dissolved off the dish with ammonium hydroxide, and poured through a filter into a crucible in which it was ignited and weighed as tungsten trioxide. The amount of tungsten trioxide obtained was not sufficient to satisfy all of the bases, but it seemed most probable that it had been united with all of the calcium and part of the iron.

To determine whether scheelite is soluble in tartaric acid, some clear crystals were broken from a specimen from Zinnwald, powdered, and

[1] Quantitative Analysis, translated by W. T. Hall, 3d edition, 1911, p. 296.

0.2250 gram heated on the steam bath with 10 grams tartaric acid dissolved in water, for two days. The amount of powder was seen to gradually decrease, and that remaining at the end of this period weighed only 0.0302 gram, representing thus only about 15 per cent of the original material. This would no doubt have dissolved completely had it been finely enough powdered, or had the heating been continued longer, so it is evident that scheelite is essentially soluble in tartaric acid. This reagent therefore can not be used to differentiate scheelite from calcite as an impurity in wolframite, but in the present case the failure to obtain an alkaline reaction on ignition seems clear evidence of the absence of calcite, so the calcium has all been regarded as in the scheelite form. As noted in the description of the mineral, a yellowish powder is visible in some cracks on the specimen; although everything of this sort was carefully removed from the material used for analysis, the presence of invisible cracks along which incipient alteration by calcium-bearing solutions has occurred is quite within the range of possibility.

The tartaric acid dissolved from the wolframite 4.16 per cent of tungsten trioxide. The 0.82 per cent of calcium oxide found would be united with only 3.40 per cent, if in the form of scheelite, so that 0.76 per cent tungsten trioxide remains to be accounted for. But 0.90 per cent ferric oxide and 0.07 manganous oxide were also found to be dissolved. The manganous oxide would take 0.23 tungsten trioxide, leaving 0.53 which was united with ferrous oxide. The amount of ferrous oxide corresponding would be, however, only 0.17 per cent (0.20 as ferric oxide), which, subtracted from the total ferric oxide found, leaves 0.70 free ferric oxide which was dissolved by the tartaric acid. This, which is perhaps present as limonite, has been listed separately in the analysis, the equivalent amount of ferrous oxide, 0.63 per cent, having been subtracted from the total ferrous oxide found. But on calculating the mineral composition of the original material, following Mr. Hess's plan of assigning the tungsten first to the manganese, calcium, magnesium, etc.,[1] a total excess of ferric oxide of 2.2 per cent was found. Since the form of the remaining 1.5 per cent of this is indeterminate, it has been necessary to include it with the ferrous oxide, although it may be present as a ferric oxide insoluble in tartaric acid, perhaps hematite, or possibly in solid solution (see below). Mr. Hess [2] has found such an excess of iron to be very frequent in wolframite.

No. 2 was fused with sodium carbonate at as low a temperature as possible, to prevent alloying of any of the copper with the platinum crucible, and then, when the oxides insoluble in water were dissolved in acid, the copper was first precipitated by hydrogen sulphide before the determination of the iron and manganese, and weighed as oxide,

[1] U. S. Geol. Surv., Bull. 583, 1914, p. 21. [2] Idem, p. 38.

after repeated ignition with dry ammonium carbonate. Here the calcium was only moderate in amount, but the columbium and tantalum oxides seemed sufficiently high to attempt to determine the relative amounts of the two.

For this purpose the oxides were fused with potassium acid fluoride, reprecipitated, and ignited as recommended by Foote and Langley [1] and the specific gravity then determined. Although the impossibility of duplicating the conditions exactly renders the result uncertain, it is probably quite as dependable as that obtained by any of the direct methods of determination. The 2.20 per cent of mixed oxides obtained had a specific gravity of 7.02, corresponding to about 2/3 tantalum, so that the percentages of the two oxides are stated as tantalic oxide 1.50, columbic oxide 0.70. No tin or titanium could be detected in either sample of wolframite.

Analyses.			Calculated mineral compositions.			
	1	2			1	2
FeO	10.81	18.18	Ferrowolframite	$FeWO_4$	39.1	75.9
MnO	12.55	3.37	Manganowolframite	$MnWO_4$	53.5	14.2
CaO	0.80	0.24	Calcioscheelite	$CaWO_4$	4.1	1.2
MgO	0.12	.....	Magnesioscheelite	$MgWO_4$	0.8	.....
CuO	.....	1.34	Cuproscheelite	$CuWO_4$	.....	5.3
WO_3	74.84	73.74	Ferrotantalite	$Fe(TaO_3)_2$	0.1	1.5
Ta_2O_5	0.26	1.50	Manganotantalite	$Mn(TaO_3)_2$	0.1	0.3
Cb_2O_5		0.70	Ferrocolumbite	$Fe(CbO_3)_2$	0.1	0.7
SiO_2	0.30	0.72	Manganocolumbite	$Mn(CbO_3)_2$	0.1	0.2
Fe_2O_3	0.70	.....	Quartz	SiO_2	0.3	0.7
			Iron oxides	Fe_2O_3, etc	1.8	.....
	100.38	99.79				
Sp. gr	7.272	7.162	Total		100.0	100.0

1. Wolframite, Cornwall, England. U. S. Geol. Surv., Bull. 583, p. 27.

2. Wolframite, Cave Creek, Arizona. *Idem*, p. 32.

In calculating the approximate mineral composition of 1 it was assumed that the only free base was the iron oxide, that the iron manganese ratio was the same in the columbite-tantalite as in the wolframite, and that equal proportions of columbium and tantalum were present.

In calculating that of 2 it was again assumed that the iron and manganese were present in the columbite-tantalite in the same ratio as in the wolframite, and that the deficiency in the summation of the analysis was due to the manganese being too low.

A few words should be added concerning the nomenclature here adopted.[2] The names wolframite, scheelite, columbite, and tantalite are used as series names, that is, as referring to any and all intermediate members of the isomorphous series, no matter what the relative proportions of the bases are. For the theoretical end members, chemical prefixes are applied to these roots.[3] This method is pre-

[1] Amer. Journ. Sci., ser. 4, vol. 30, 1910, p. 393.

[2] Which represents an extension of that proposed in Science, vol. 39, 1914, p. 575.

[3] The end members are described as theoretical because they can not be expected to occur in nature, elements being apparently never found free from at least small amounts of their isomorphs. Their chemical-prefixed names should therefore not be included in "lists of new mineral names."

ferred to the use of distinct names for the end members because, while both are ambiguous in being ordinarily used for quite distinct things, it seems simpler to restrict the chemical terms to one meaning. Thus, both ferrowolframite and ferberite may be used either for pure ferrous tungstate, or for a ferrous tungstate containing a little manganese isomorphously replacing the iron; manganowolframite and hübnerite for either pure manganese tungstate or manganese tungstate containing a few per cent of iron in isomorphous replacement; cuproscheelite and cuprotungstite for various mixtures of copper and calcium tungstates, etc.

If mineralogy is ever to have anything like a quantitative system of nomenclature, such ambiguity will have to be avoided, and it seems to the writer that the best way to avoid it will be through restricting the use of words with chemical prefixes to the end members, whether found in nature or not, and doing away with distinct names for them. The method used in the well-known quantitative classification of igneous rocks could be adopted here, using the prefixes: Permangano when Mn: Fe is greater than 7: 1; domangano between 7:1 and 5:3; ferromangano between 5:3 and 3:5; doferro between 3:5 and 1:7; and perferro less than 1:7. Named according to this plan, the wolframite from Cornwall would be ferromanganowolframite and that from Cave Creek doferrowolframite. Such names are of course too cumbersome for everyday use, although it is possible that in certain cases they might be employed with advantage for purposes of classification or comparison. It is especially urged, however, that they, like those of end members, be omitted from lists of mineral names, for arbitrarily partitioned-off portions of isomorphous series are not to be regarded as definite minerals.

It is of course impossible to refer in the names to all constituents of the minerals, but that does not mean that some of the minor ones are not of considerable importance; and the significance of the columbium and tantalum found in these samples is certainly worth discussing. In the table of calculated mineral compositions these have been regarded as united with iron and manganese, to form the columbite and tantalite molecules. No columbite and tantalite are present as visible inclusions, for the brilliant cleavage surfaces of the wolframites look perfectly uniform under the microscope. But they might exist either 1, in chemical combination; 2, as submicroscopic inclusions; in one of the types of solid solution: 3, isomorphous replacement; or 4, mix crystals; or, finally, 5, as an adsorption compound. The tendency of the "metallic acids"—columbium, tantalum, titanium, tungsten, vanadium, etc.—to enter minerals in these ways is very evident when the variability in composition of many columbates, of the titaniferous magnetites, etc., is considered. But various interpretations have been put on it by different observers.

Thus Dr. J. T. Singewald, jr.,[1] concluded that the presence of titanium in magnetites showing no visible ilmenite intergrowths proved the existence of a "titanomagnetite"; but he had found the lamellas of ilmenite to vary continuously from 4 mm. down to 0.001 mm. in length, and there is no reason at all why they should cease to exist at just the latter size, for the limit of microscopic visibility is determined by the wave length of light, and has no significance as far as the molecules are concerned, a particle of this size containing thousands of molecules. So submicroscopic inclusions may well account for much of the titanium. Stopford Brunton,[2] from similar studies, assumed the titanium to be present in "solid solution," but evidently used this term to cover all cases where no inclusions are visible, making no attempt to differentiate the various possibilities listed above. It seems to the writer that we should be more specific in stating just what mode of combination the evidence favors in any particular case, so the data in regard to wolframite will be further discussed here.

The absence of the elements columbium and tantalum from some specimens of the latter mineral, and their variable amount when found, clearly indicate that they are not chemically combined with the tungstates. That their presence might be due to inclusions of columbite and tantalite has been suggested,[3] without definite proof; and only the existence of visible inclusions would justify the assumption of submicroscopic ones, as in the titaniferous magnetites above mentioned. There remain, therefore, only the possibilities of solid solution and adsorption, 3, 4, and 5.

A solid solution, according to van't Hoff, the first to employ the term, is a solid homogeneous complex of two or more substances, the relative proportions of which may vary, but the homogeneous character be retained.[4] Two principal types can be distinguished, isomorphous replacement, where the substances are closely related chemically and may be regarded as taking one another's places in the point system constituting the crystal structure; and mix-crystal formation, where the substances are so different in character that mutual replacement is out of the question. The formation of mix crystals, in which, as has been shown more especially by O. Lehmann,[5] two or more crystalline substances grow together so intimately that they appear homogeneous under the microscope, yet mutually affect one another as to crystallization, producing changes in habit, crystal angle, optical properties, etc., is probably a much more frequent and important phenomenon than is ordinarily supposed. It takes the

[1] Econ. Geol., vol. 8, 1913, p. 207; U. S. Bureau of Mines, Bull. 64, 1913.
[2] Idem, p. 670.
[3] Damour, Bull. soc. géol. France, ser. 1, vol. 2, 1848, p. 108; Hess, *loc. cit.*
[4] Zeits. phys. Chemie, vol. 5, 1890, p. 323.
[5] Zeits. Kryst. Min., vol. 1, 1877, p. 453; vol. 6, 1882, p. 48, p. 580; vol. 12, 1887, p. 399, etc.

place in crystalline substances that adsorption does in colloids, and, indeed, is probably the same effect. At least it is among the elements the compounds of which show the greatest tendency to take on the colloidal form that mix crystal formation is most frequent.

Tungsten and columbium are alike only in that both can act as anions toward the more strongly electro-positive elements, and different in practically every other chemical property—in valence, behavior with reagents, etc.—so that they can not be expected to replace each other isomorphously. The most reasonable explanation of the condition of the columbium and tantalum oxides in wolframite is, then, that they are present as mix crystals, or, in other words, that the several point systems have interpenetrated to such an extent that they have become at least pseudohomogeneous.[1] Wolframite is of course not susceptible to optical examination, nor can any crystal angle measurements be made on the present specimens, but if they could be so studied effects such as those shown by other mix crystals would no doubt be observed. Such intergrowth produces marked effects on the crystal angles of the columbite group of minerals, which, as will be more fully explained elsewhere, are probably to be regarded as composed of mix crystals of a very few fundamental compounds; the principal ones, the compositions of which are $R''Cb_2O_6$ and $R''Ta_2O_6$, are trimorphous, having isometric, tetragonal, and orthorhombic forms; so that, even admitting that the analyses of members of this group are to some degree correct, the number of "species" into which it should be separated is greatly overestimated.

In summary, two wolframites have been analyzed and their compositions discussed, a standard nomenclature for such isomorphous mixtures recommended, and the columbium and tantalum oxides found shown to most probably exist in mix crystal form.

A NEW OCCURRENCE OF BERAUNITE.

The rare iron phosphate beraunite was discovered near Hellertown, Northampton County, Pennsylvania, by the department of geology of Lehigh University in 1911. The exact locality is the northeast corner of an abandoned iron-ore pit, 1 mile southeast of the center of the town. It was analyzed by Mr. J. S. Long, assistant in the department of chemistry, and later more thoroughly studied by Mr. Louis H. Koch, assistant in mineralogy, as part of the work for his degree of master of science at Lehigh. Specimens were brought by the writer to the United States National Museum (Cat. No. 87284), and further investigated and the combined results of all the work are here presented.

[1] The apparent excess of iron oxides, if not due to analytical errors, may be explained in the same way, which would be favored by their similar crystallization: Prior, Mineralogical Magazine, vol. 13, 1903, p. 217.

The material shows a deep brown nodular crust up to 5 mm. thick, and flat radiations up to 1 cm. in diameter, on the surface of an iron-stained quartzite. In some specimens it bears implanted globules of psilomelane, yellow needles of cacoxenite, and powdery clay. Internally the crusts are coarsely fibrous, with the fibers perpendicular to the surface, and the material was evidently originally a gelatinous precipitate, which has become hard and crystalline in place, thus representing a "meta-colloid," as defined by the writer in a recent paper.[1]

After a preliminary analysis (1) had shown the general nature of the mineral, material for further study was obtained by crushing selected fragments, and the powder looked completely crystalline and homogeneous under the microscope, except for the presence of a trace of clay or fine sand. Standard methods of analysis were used, the iron being determined with permanganate, the manganese by the bismuthate and the Ford methods, and the phosphorus weighed as magnesium pyrophosphate after separation by molybdate. A small amount of water—less than 0.5 per cent—was given off below 100°, and the analyses were made on coarsely powdered material dried at this temperature, for the fineness of the grinding and the humidity of the air were found to have a distinct effect on the water content.

Table of analyses.

	1	2	3	4	5	6	7
Fe_2O_3	42.91	52.65	55.61	57.80	57.89	58.69	4.5
Mn_2O_3	15.25	3.88	1.80	1.66			50.5
P_2O_5	28.10	29.27	28.53	27.43	28.33	28.71	3.2
H_2O	10.01	13.59	13.54	12.60	12.43	12.60	22.1
SiO_2	4.02	0.71	0.34	0.55	1.41	.....	12.0
	100.29	100.10	99.82	100.04	100.06	100.00	(92.3)

1. Analysis by J. S. Long.
2. Analysis by Louis H. Koch.
3, 4. Analyses by the writer.
5. Average of the preceding, uniting Fe_2O_3 and Mn_2O_3, which are evidently isomorphous.
6. Same, corrected by removing the SiO_2 and recalculating to 100°. Ratios, $R_2O_3:P_2O_5:H_2O = 1.82:1:3.47$.
7. Partial analysis of the associated psilomelane, by Mr. Long. Alkalies and alkaline earths present but not determined.

These analytical results apparently do not indicate any simple, fixed formula for the mineral, nor do they establish its identity with any previously described species; although inspection of the analyses, and the formulas derived from them, of the various "species" of ferric phosphates in Dana's System, shows that similar difficulties have been encountered in this group of minerals before. The Hellertown mineral agrees in specific gravity and optical properties, how-

[1]Journ. Wash. Acad. Sci., vol. 4, 1914, p. 112.

ever, with beraunite. The specific gravity, determined by a pycnometer, varied from 2.850 to 2.920; Dana gives 2.95. The indices of refraction were found to be approximately α and $\beta = 1.78$, $\gamma = 1.81$, extinction straight (elongated parallel to b.), and sign of elongation —. No optical data have been published for beraunite, but Dr. E. S. Larsen, of the United States Geological Survey, kindly examined for comparison a specimen of the variety "eleonorite" (U.S.N.M. Cat. No. 80622) from the type-locality at Giessen, Germany, and obtained the values: $\alpha = 1.775$, $\beta = 1.786$, $\gamma = 1.815$, which are essentially the same as those above given.

Two possible explanations of the variation in composition shown suggest themselves. The first, that the law of definite proportions does not hold in this, and other iron phosphates, would be capable of introducing a rather chaotic condition into mineral chemistry, and seems entirely improbable. If the mineral were a colloid, however, the results could at once be interpreted in a second way—that the mineral is an adsorption compound of ferric and manganic hydroxides with phosphoric oxide and water. It is, however, a meta-colloid, that is, a colloid which has become crystalline without dissolving or losing its solidity. If, when this crystallization took place, the adsorbed constituents united as well as they could into definite compounds which formed mix crystals (or, as it is often called, solid solution), the results obtained could easily be accounted for.

The R_2O_3:P_2O_5 ratio shown here varies from 1.72:1 in No. 2 to 1.93:1 in No. 1, while that indicated by the best previous beraunite analyses is 1.50:1, and the best dufrenite analyses, 2.00:1. The simplest explanation of the variation and indefinite ratios shown by the specimens under investigation is that they represent mix crystals (solid solutions) of these two fundamental compounds. The dufrenite molecule is in excess over the beraunite, although the properties are those of the latter mineral; it might therefore be called dufreniberaunite.

AXINITE FROM DELAWARE COUNTY, PENNSYLVANIA.

In the pegmatite cutting the granite gneiss of the Leiper Quarry at Avondale, Delaware County, Pennsylvania, an occurrence of the mineral axinite has been discovered, certain features of which are so unusual that it has seemed worth while to make it the subject of special study and description. It was in fact at first supposed to be a new mineral, and its true character was only recognized toward the end of the investigation.

Specimen 1 (U.S.N.M. Cat. No. 87232) consists of three small fragments, showing a columnar mineral with a resinous luster, of a pale yellow to salmon pink color, associated with pink microcline, granular

quartz, and muscovite. It was found at the locality in 1904, and analyzed by the writer when beginning the study of quantitative analysis. The results, given in column 1*a* in the table below, showed it to have a composition distinctly different from that of any previously known mineral, although, because of lack of experience, it is probable that they are not altogether accurate, some silica having no doubt been weighed with the sesquioxides, and some manganese with the calcium or magnesium; but the boric acid, having been determined by the writer's volumetric method,[1] is probably exact. The matter was then laid aside because of the pressure of other work, but when the writer became connected with the Museum, it was taken up again. To obtain a check on the previous analysis, all the mineral that could still be broken from the specimens, amounting to less than half a gram, was sent to Mr. J. E. Whitfield, of the firm of Booth, Garrett & Blair, of Philadelphia, who has been doing considerable analytical work for the Museum, and his results are given in column 1*b*.

Meanwhile a mass of yellow plates, about 4 by 2 by 1 cm. in size, was found at the quarry by Mr. J. Watts Mercur, jr., of Wallingford, Pennsylvania. (U.S.N.M. Cat. No. 87233). Although showing no planes definite enough for crystallographic measurement, this material had the aspect of axinite, and the same specific gravity, 3.250. A clear fragment was sent to Mr. Whitfield for analyis, and he obtained the results in column 2*a*; but as the boric acid seemed rather low, probably owing to incomplete decomposition, two determinations were made by the writer, and 5.98 and 6.09, average 6.04, obtained (column 2*b*). Using this value, the agreement with the theory for axinite is so close as to leave no doubt that it is the mineral represented.

The question as to whether No. 1 was a new mineral, or only an impure axinite, remained unsolved, so powder from both specimens was submitted to microscopic examination. No. 2 showed a mean index of refraction of 1.680, birefringence 0.008, and sign −, thus agreeing with typical axinite. The greater part of No. 1 gave essentially the same values, but scattered through this material could be seen pinkish, pleochroic grains with a much higher index, 1.700, but still lower birefringence, 0.005, showing, in fact, ultrablue interference colors, also extinguishing straight and + in sign. These properties identified it as zoisite, a mineral which had previously been reported from the locality.[2] Here, then, was the explanation of the difference between analyses 1*a* and 1*b*, as well as their deviation from the theory for axinite: the material is not homogeneous, but contains a variable

[1] Journ. Amer. Chem. Soc., vol 30, 1908, p. 1687.

[2] Cardeza, Proc. Acad. Nat. Sci. Phila., 1892, p. 194; discovered by Miss Mary S. Holmes. A small specimen of this mineral, not associated with axinite, collected by the writer about 1906, has also been added to the Museum collection (Cat. No. 87234).

amount of intergrown zoisite. And the theoretical composition of a mixture of 80 per cent axinite with 20 per cent zoisite, given in the last column, corresponds, in a general way, with the analytical results.

Table of analyses.

	1*a*	1*b*	2*a*	2*b*	3	4
CaO	22.47	20.00	19.98	.....	19.66	20.48
MnO	3.26	5.19	10.12	.....	9.94	5.17
FeO	3.39	3.16	3.80	.....	2.49	5.19
MgO	2.68	1.55	1.01	.....	.....	.....
K_2O	0.65	n.d.	.....	.....	.....	.....
H_2O	1.76	n.d.	0.57	.....	1.58	1.65
Al_2O_3	[22.93]	22.64	18.78	.....	17.91	20.54
B_2O_3	5.45	n. d.	3.14	6.04	6.14	5.12
SiO_2	37.41	42.92	42.24	.....	42.28	41.85
	100.00	(95.46)	99.64	.....	100.00	100.00

1*a*. Analysis of a portion of specimen 1, by the writer; MnO and SiO_2 probably too low.
1*b*. Analysis of another sample from the same, by Mr. Whitfield.
2*a*. Analysis of axinite, specimen 2, by Mr. Whitfield.
2*b*. Result of determination of boric oxide in the same, by the writer.
3. Theoretical composition of an axinite in which Mn:Fe = 4:1. Compare with 2*a* and 2*b*.
4. Theoretical composition of an axinite in which the Mn:Fe ratio is 1:1, mixed with 20 per cent of zoisite. Compare with 1*a* and 1*b*.

To find zoisite and axinite intimately intergrown is rather unexpected, but unfortunately the material available is too limited to study the relations between them. It looks as if the zoisite had determined the columnar habit, as well as the pinkish color, and so given reason for the original supposition that a new mineral was represented.